

WHAT IS CLAIMED IS:

1. A scanning probe microscope for imaging the surface of a sample,
comprising:

a sensor comprising an oscillator for producing a signal;

5 a probe connected to the sensor;

an optical microscope for viewing the location of the probe mounted to the sensor;

means for scanning the probe with respect to the sample;

sensor electronics connected to the sensor for monitoring the signal produced by
the sensor; and

10 means responsive to the signal produced by the sensor electronics for moving the
probe toward or away from the surface of the sample.

2. The scanning probe microscope according to claim 1 wherein the oscillator is a
resonant crystal oscillator..

3. The scanning probe microscope system according to claim 2 wherein the
15 resonant crystal oscillator is a quartz crystal cross oscillator.

4. The scanning probe microscope according to claim 2 wherein the resonant
crystal oscillator is self-excited.

5. The scanning probe microscope according to claim 3 wherein the quartz crystal
cross oscillator is self-excited.

20 6. The scanning probe microscope according to claim 2 wherein an external
modulator is provided proximate to the resonant crystal oscillator, and further comprising
an excitation circuit for supplying an excitation signal to drive the modulator.

7. The scanning probe microscope according to claim 3 wherein an external modulator is provided proximate to the quartz crystal cross oscillator, and further comprising an excitation circuit for supplying an excitation signal to drive the modulator.

8. The scanning probe microscope according to claim 1 wherein the scanning
5 probe microscope is operable in a mode selected from the modes of magnetic force microscopy and electrostatic force microscopy and the signal produced by the sensor is used to determine characteristics of the sample selected from among the characteristics of magnetic and electrostatic properties, respectively.

9. The scanning probe microscope according to claim 1, further comprising a
10 holder for the sensor that facilitates rapid probe exchange.

10. The scanning probe microscope according to claim 1 wherein the oscillator is operated at substantially its resonance frequency.

11. The scanning probe microscope according to claim 10 wherein the resonance frequency is greater than 400 kHz.

12. The scanning probe microscope according to claim 1 wherein the oscillator
15 operates in a in a shear force mode by vibrating the probe approximately parallel to the surface of a sample.

13. The scanning probe microscope according to claim 1, further comprising a cantilever and wherein the probe is mounted to the cantilever and the cantilever is in turn
20 mounted to the sensor to connect the probe to the sensor.

14. The scanning force microscope according to claim 1 wherein the means for scanning the probe with respect to the sample comprises a first electromechanical

transducer and a second electromechanical transducer, the first electromechanical transducer having a first resonant frequency and the second electromechanical transducer having a second resonant frequency substantially lower than the first resonant frequency, and wherein the means responsive to the signal produced by the sensor electronics for
5 moving the probe toward or away from the surface of the sample comprises a third electromechanical transducer having a third resonant frequency substantially higher than the first resonant frequency.

15. The scanning force microscope according to claim 14 wherein the first electromechanical transducer scans in an X direction and has a resonant frequency $R(X)$,
10 the second electromechanical transducer scans in a Y direction and has a resonant frequency $R(Y)$, and the third electromechanical transducer scans in a Z direction and has a resonant frequency $R(Z)$, and $R(Z) \gg R(X) \gg R(Y)$.

16. The scanning force microscope according to claim 15 wherein the electromechanical transducers are piezoelectric ceramic actuators.

15 17. The scanning force microscope according to claim 15 wherein the first electromechanical transducer is a voice coil and the second and third electromechanical transducers are piezoelectric ceramic actuators.

18. The scanning probe microscope according to claim 1 wherein the means responsive to the signal produced by the sensor electronics for moving the probe toward
20 or away from the surface of the sample comprises a first feedback loop for producing a first control signal, a first electromechanical transducer having a first resonant frequency, a second feedback loop for producing a second control signal, and a second

electromechanical transducer having a second resonant frequency, the first resonant frequency being lower than the second resonant frequency.

19. The scanning probe microscope according to claim 18 wherein the first electromechanical transducer is employed to level the surface of the sample with respect
5 to the sensor, whereby a range of motion imparted by the second electromechanical transducer to the probe is small.

20. The scanning probe microscope according to claim 14 wherein the motions imparted by the first and second electromechanical transducers to the probe are orthogonal to the motion imparted to the probe by the third electromechanical transducer,
10 whereby a range of motion imparted by the third electromechanical transducer to the probe is small.

21. A scanning probe microscope for imaging the surface of a sample, comprising:

a sensor comprising an oscillator for producing a signal;
15 a probe connected to the sensor;

means for scanning the probe with respect to the sample comprising a first electromechanical transducer and a second electromechanical transducer, the first electromechanical transducer having a first resonant frequency and the second electromechanical transducer having a second resonant frequency substantially lower than
20 the first resonant frequency;

sensor electronics connected to the sensor for monitoring the signal produced by the sensor; and

means responsive to the signal produced by the sensor electronics for moving the probe toward or away from the surface of the sample comprising a third electromechanical transducer having a third resonant frequency substantially higher than the first resonant frequency.

5 22. The scanning force microscope according to claim 21 wherein the first electromechanical transducer scans in an X direction and has a resonant frequency $R(X)$, the second electromechanical transducer scans in a Y direction and has a resonant frequency $R(Y)$, and the third electromechanical transducer scans in a Z direction and has a resonant frequency $R(Z)$, and $R(Z) \gg R(X) \gg R(Y)$.

10 23. The scanning force microscope according to claim 21 wherein the electromechanical transducers are piezoelectric ceramic actuators.

 24. The scanning force microscope according to claim 21 wherein the first electromechanical transducer is a voice coil and the second and third electromechanical transducers are piezoelectric ceramic actuators.

15 25. The scanning probe microscope according to claim 21 wherein the motions imparted by the first and second electromechanical transducers to the probe are orthogonal to the motion imparted to the probe by the third electromechanical transducer, whereby a range of motion imparted by the third electromechanical transducer to the probe is small.

20 26. The scanning probe microscope according to claim 21, further comprising an optical microscope for viewing the location of the probe mounted to the sensor.

27. A method for operating a scanning probe microscope for initiating scanning the surface of a sample, comprising the steps of:

providing a sensor comprising an oscillator;

operating the oscillator over a range of frequencies;

5 determining the amplitude of current over the frequency range;

selecting a frequency from a current versus frequency curve;

using an optical microscope to position a probe connected to the oscillator with respect to a region of the sample surface to be scanned;

moving the probe toward the sample as the oscillator vibrates the probe;

10 detecting an acoustic frequency produced by the oscillator as the vibrating probe is moved to within approximately 100 nanometers of the sample;

detecting atomic force interaction when the probe is moved into proximity with the sample; and

scanning the sample after the probe is detected to be in proximity to the sample.

15 28. The method of claim 27 wherein the frequency at which the oscillator is operated is different from the frequency used for scanning.

29. The method of claim 27, further comprising the step of raising the probe so that the probe does not follow the surface on retrace during raster scanning.